Collaboration in the supply chain: A need for a new technology paradigm

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Abstract. 'Just-in-case inventory' is one of the traditional methods of reducing uncertainty in business. The unfortunate consequence of this approach is the bullwhip effect. An alternative approach is some form of collaborative scenario. Unfortunately, neither approach guarantees optimisation across the supply chain. The fundamental reason for this is found in the rational behaviour that participants in the process adhere to. As it is impossible to suppress rational behaviour, a solution for this problem is sought through orchestration and rigorous implementation of the Collaborative Planning, Forecasting and Replenishment (CPFR) process. A technology that promises to facilitate this objective is a Service Oriented Architecture (SOA) based on web services. However a new paradigm, more suited to collaborative business scenarios, is needed. Pi-calculus, coupled with Business Process Modelling and web services, seem to offer a solution. This paper sketches the direction for future research.

1. Introduction

Over the last decade and half, the world of business and industry witnessed numerous technology based attempts to increase its competitiveness. Unlike the initiatives that preceded this phase, which were mainly concentrated on revenue generation, this particular phase was almost exclusively cost focused. Streamlining, downsizing, business process reengineering, core competence and other buzzwords became a part of everyday jargon. Most of these initiatives rely on some sort of enabling technology, designed to make businesses more competitive and more profitable. Unfortunately, despite major efforts, profitability remains a challenge. An alternative approach, focused on customers relationship management paradigm has been introduced, but also has failed to make a step change.

In parallel with this latest effort, another paradigm started to emerge. Rather than trying to continue to focus on competitive pressures, which seem to provide diminishing returns, business started to see collaboration as a major differentiator. A realisation that value is created not only inside the boundaries of one organisation, but across the whole supply chain, has slowly, but surely begun to gain momentum. As always, technology is maturing and enabling this shift in philosophy, but some concerns and obstacles remain. The objective of this paper is to focus on several of these challenges and explore whether successful implementation of some of the collaborative scenarios in the supply chain is possible. A particular scenario examined is called Collaborative Planning, Forecasting and Replenishment (CPFR).

The paper will initially focus on behavioural issues causing supply chains to act inefficiently and will explore whether new collaborative paradigms have embedded solutions to address such issues automatically. Specifically, this paper will explore the phenomena known as the bullwhip effect and the tragedy of the commons and the reasons for their existence in the supply chain intimated. The paper then scrutinises some of the more recent initiatives, such as the VICS (Voluntary Inter-industry Commerce Standards) guidelines for CPFR implementation, in order to establish whether the above phenomena are addressed by such initiatives. The last section moves towards areas of future research. All current technologies, procedures and architectures for providing maximum efficiency and effectiveness were designed to work in a competitive environment. It is not necessarily easy to deduce what solutions are needed to improve efficiency and effectiveness in a collaborative environment. This paper intends to provide just preliminary glimpses and hints about the direction of future research in this domain.

2. Preliminary situation analysis

Supply chain issues are as old as the history of business venture. One particular, and not so new, phenomenon affecting every supply chain is inventory stockpiling. Whilst inventory minimisation is a known strategy for improving financial results, the reduction in inventory also yields an increase in exposure to uncertainty, which is difficult to manage. Uncertainty is one of the most undesirable attributes of any business and businesses usually endeavour to minimise it as much as possible. The solution, to many, is the adoption of a common sense, or '**just in case inventory'** approach *(deMin 2004)*. However, this traditional 'just in case' inventory strategy, which reduces the level of uncertainty, has an unpleasant consequence on the supply chain, known as the ***bullwhip effect*** *(Lee, Padmanabhan et al. 1997).* The bullwhip effect can be seen as a result of the safety margins applied to inventory management by all the participants. Every member in the supply chain tries to handle uncertainty and the risk associated with it by adding a safety margin to their stock. However, moving up the supply chain, these safety margins get compounded, as everybody adds a safety margin on top of the existing safety margin. In order words, the further we go upstream, the greater the variance of orders, and consequently, the greater the relative increase in inventory levels.

In today's environment, the bullwhip effect is not only a result of uncertainty associated with lead times (due to order acceptance, manufacturing time, shipping time, etc.). It is also heavily influenced, and even more exaggerated, by some contemporary marketing tactics (promotions, two-for-one, new product enhancements and releases, etc.). Even if the perfect method of optimisation were invented to handle this problem, the bullwhip effect would remain one of the most difficult ones to eradicate. Why?

A simple reason is that the decisions that drive the bullwhip effect are a representation of the most rational behavioural pattern. Taking a safety margin into one's estimates is one of the most rational courses of action. Needless to say, we are only talking about rationality on an individual level. When this 'rationality' is compounded across the chain, the net effect is a complete breakdown of the objective function. Rational behaviour, when applied in isolation, can lead to chaos, just as irrational behaviour can.

The notion of individual rationality applied in isolation is not new, and it appeared in other disciplines under a somewhat different cloak. An alternative expression for, more or less, identical behaviour is known as ***the tragedy of the commons*** phenomenon. The notion of the tragedy of the commons goes back to Aristotle. It has been revamped during the mid nineteenth century by William Forster Lloyd and put into a contemporary context during the late sixties by an ecologist, Garrett Hardin *(1968).* The basic idea is built around an assumption that a number of herdsmen (sic!) keep their cattle on the commons. As a rational being, every herdsman is trying to maximise his gain. This means that each and every one of them is thinking of adding one more animal to his herd. From the individual point of view, this is just a maximisation of utility. The problem happens when they all follow this course of action and "freedom in a commons brings ruin to all", as Hardin put it. The tragedy of the commons, just like its complement the bullwhip effect, implies that individual rational behaviour can have catastrophic consequences if applied in isolation.

The alternative to this approach, and the participants in the supply chain know this intuitively, is some form of collaboration with one another. Unfortunately, collaborative supply chain management also implies that overall inventory across the supply chain is a form of the common good and demands that all participants are acting in good faith with the common objective of reducing overall supply chain costs with particular emphasis, in this context, on overall inventory optimisation. It has been proven by von Neumann, J. and Morgenstern O. *(von Neumann and Morgenstern 1947)*, that it is impossible to maximise, or minimise, two variables simultaneously. The only solution is some form of optimisation, subject to certain constraints. Unfortunately, because of this optimisation principle, we can never simultaneously minimise our own inventory and the total value of the inventory across the supply chain. If the objective function is the minimisation of the overall level of the supply chain inventory, then one person's individual inventory level is bound to be higher than it would be if they tried to minimise it in isolation from other participants in the supply chain. Effectively, individual inventory, although it plays an important role in the supply chain, is of a lesser importance than the overall inventory level across the chain. This is an unpalatable fact from individual point of view. The hopeful notion that follows from this fact is: if one person's inventory is going to go up for the sake of overall savings in the supply chain, then these overall savings must be greater than the costs associated with the increase in inventory. Or to put it differently, the rewards from participating in the collaborative supply chain scenario must be perceived to be higher than the potential reward (or loss) that comes from independent inventory optimisation strategy. The problem with this assumption is that nobody can guarantee it. So, are individual participants likely to behave in this case?

Tentatively, the answer to this question can be found in Tversky & Kahneman's **Prospect Theory** *(Kahneman, Slovic et al. 1982).* Kahneman, Slovic and Tversky showed, in simple terms, that people tend to avoid risk when seeking gains and chose risk to avoid losses. The above two scenarios (individual inventory management and collective supply chain management scenario) do not seem to have congruent objectives. The individual inventory management strategy relying on the 'just in case inventory' philosophy is a prime example of the gain seeking principle. In other words, the businesses **seek to maximise sales** and will **avoid risks** that having a low level of inventory brings in this context. The collaborative supply chain management is primarily a loss avoidance strategy. In other words, the businesses are trying to **avoid losses** that high inventory level brings and are prepared to **take risks** associated with lower level of inventory. However, what do we actually mean by collaboration in the supply chain?

Collaboration related to inventory in the supply chain, in practice, often means an increase in visibility and some form of negotiation leading to a consensus. Increase in visibility alone can reduce the level of inventory, and the costs associated with it, without any increase in uncertainty. Carlsson and Fuller's *(2000)* theorem proves that by increasing the visibility of demand statements through the supply chain, the variances of the suggested optimal orders will get smaller. Does that mean that the increase in visibility automatically neutralises individual rationality? Even more importantly, what happens with the negotiations part of collaborative behaviour and what are the consequences of seeking consensus in the supply chain?

Collaboration is more than a method of sharing information. It is a method of working together towards one single goal. However, although participating companies might have one goal, their circumstances, constraints and possibly even strategies how to achieve this common goal might differ. As they have no power to change the circumstances or constraints, the only element that is negotiable is the strategy of how to achieve the goals, i.e. to seek the consensus. Seeking consensus through negotiations, therefore by definition, implies applying rational thinking. As there is no guarantee that the strategy will work, the most rational option is protect oneself against potential losses. The individual rationality is back, and it will manifest itself through either the bullwhip effect or the tragedy of the commons. Clearly, the problem that potentially occurs in collaborative scenarios is exactly the same as the one that occurs in individual inventory management scenarios, that is: neither strategy eliminates uncertainties related to the final demand and the individual rationality will dominate and ruin the common good. The enabler for this rationality to resurface in collaborative scenarios is the negotiation part of the concept of collaboration. Astonishingly, whether we apply separate inventory management strategies or apply collaborative supply chain management strategies, we end up with the same problem. Both strategies, potentially, lead to inefficiencies and fail to deliver the expected results. Even more ironically, the reason for failure, in both cases, stems from highly rational behaviour. As it is illogical to expect that the participants will act irrationally, does that mean that we stand no chance of optimising inventory across the supply chain?

3. Collaborative Planning, Forecasting and Replenishment (CPFR)

Historically, a number of management techniques were used to manage inventory successfully (Barratt and Oliveira 2001). One of the more recent initiatives gaining significant momentum in industry is Collaborative Planning Forecasting and Replenishment (CPFR). In its simplest form, CPFR as a typical SCM (Supply Chain Management) strategy, seeks to reconcile production planning and associated inventories with customer demand. Demand management, as such, becomes a key issue. Beside the inventory reduction, CPFR is also expected to reduce out-of-stock items, improve asset utilisation, and rationalise deployment of resources. However, its usage is still not widespread and, where implemented, the results are not always encouraging *(Stank, Daugherty et al. 1999).*

As there is no single definition of CPFR, we offer a tentative definition of CPFR as **a process and a business practice** relying on technology and procedures, aiming to produce one **unified statement of demand** and endeavouring to maintain optimum levels of inventory across the supply chain through **sharing and reconciling forecasts**. CPFR was first applied in 1995 when Wal-Mart formed a working group with Warner Lambert to pilot a new approach on collaborating in forecasting and replenishment of one of the products (Listerine)[1]. It proved successful and it created many expectations. In addition to the primarily internal and cost focused drivers mentioned above, other external factors also drive the adoption of CPFR, such as: improvement in overall chain competitiveness, transparency and cost structure, ability to cope with fashion trends (or shortening of product life cycle), possibility to cope with moves to offshore production, and a need to handle increasingly longer, global supply chains *(Fliedner 2003).* Marginal CPFR benefits come from increases in sales, improvement in both trading partner relationships and communication, and improvements in service level.

In order to ‘regulate’ and promote good practice in implementing CPFR, in 1998 the Voluntary Inter-industry Commerce Standards (VICS) Association launched one of the most comprehensive sets of guidelines in this domain. In an effort to globalize CPFR, in 2000 VICS teamed up with ECR Europe (Efficient Consumer Response).

[1] For details see <http://www.gmabrands.com/industryaffairs/docs/cpfr.pdf>. Accessed: Oct 2004.

Despite some modifications, the original CPFR Nine-step Process Model still constitutes the core of the Guidelines[2]. The nine-step VICS CPFR process model includes the following:

1. Establish a collaborative relationship
2. Create a joint business plan
3. Create sales forecasts
4. Identify exceptions from the sales forecasts
5. Resolve/collaborate on the exception items
6. Create order forecasts
7. Identify exceptions from the order forecasts
8. Resolve/collaborate on the exception items
9. Generate order

Despite prescribing the procedure in great depth, the CPFR concept has not been too widely implemented. Why? Barratt and Oliveira *(2001)* identified a number of barriers associated with the implementation of CPFR, such as:

- No shared targets
- Difficulty to manage the forecast exception/review processes (in both sales and order forecasts)
- Trading partner focuses on the traditional supply chain steps, not on the exception/review processes
- Promotions and new items events are not jointly planned
- Non-existence of an integrated decision support system to provide consumer, customer and market data
- No adequate information technology/expertise
- Lack of discipline to execute preliminary (and preparatory) phases of the CPFR process (in particular, in the stages of issuing the front-end agreement and the joint business plan)

In addition to these, Fliedner *(2003)* identified other issues, such as:

- Lack of trust in sharing sensitive information
- Lack of internal forecast collaboration
- Fragmented information sharing standards
- Aggregation concerns (number of forecasts and frequency of generation)
- Fear of collusion

From this paper's point of view, one of the most fundamental problems of the VICS CPFR process model is that it does not close the door to **individual rationality**. Particular problems are steps 3 to 9, which try to encourage negotiations in order to eliminate exceptions and find consensus. VICS CPFR Guidelines acknowledge that buyers and sellers have different views of the marketplace. The assumption is that by exchanging information and negotiating consensus, these differences can be overcome and the end result is a single shared forecast of both the order forecast and the sales forecast. This is the part that is particularly problematic. The notion that one party

[2] For details see <http://www.cpfr.org/documents/pdf/CPFR_Tab_2.pdf>. Accessed: Oct 2004.

generates sales forecasts, communicates the results to the other party, collaborates upon, and then uses the negotiated numbers as a baseline for the creation of an order forecast, does not make sense.

Effectively the word ‘collaboration’ has been interpreted as a **method of reconciliation** of the forecasts between the participants in the chain. In a way, CPFR forecasts are almost treated as the **consensus forecasts**. The idea that through the negotiations, the participants will resolve exceptions and reduce the safety margins built into their individual forecasts, which will eventually eliminate potential risks of creating chaos in the system, cannot stand the scrutiny. If the CPFR forecasts are treated as consensus forecasts, then by definition this means that rationality is the foundation stone on which they were built. According to our premises, this foundation stone is crooked and the whole superstructure is likely to collapse. If this is the case, what is the solution?

4. Moving towards a solution

From the above exposition it is quite evident that the concept of individual rationality is a major stumbling block in an optimisation process and, therefore, the solution sought is the elimination of such rationality. As it is counterintuitive to expect that anyone will abandon rational behaviour, the fundamental question we need to resolve is: how do we eliminate individual rationality from the process?

The notion of rationality is implicit to human behaviour, so the only likely option is to remove the need for human intervention from the process. Generally speaking, people will intervene when there is a need to reconcile something. In our context, this means that the need to reconcile forecasts has to be eliminated.

From our definition of CPFR, the participants in the supply chain aim to produce one unified statement of demand. This means that there should be only **one perception** of the ultimate truth, i.e. the final demand. As nobody knows what this demand will be, the only two things the participants have to agree upon (collaborate, reconcile, negotiate or seek consensus) are:

- What approach to (or method of) forecasting is to be used?
- How should the quality of demand forecasts be assessed?

All the remaining issues can be converted into a straightforward optimisation problem, i.e. calculation of individual levels of inventory defined by individual and collective constraints. The sharing and the reconciling part of our definition of CPFR (“… endeavouring to maintain optimum levels of stocks across the supply chain through sharing and reconciling forecasts”) applies to sharing the constraints whilst the part on reconciling the forecast functions, becomes more like a goal-seeking scenario from the world of optimisation.

The solution advocated in this paper is: **forecast (extrapolate) once and calculate (optimise) many times**. Essentially, by forecasting once and calculating as many times as necessary, we have eliminated a need to intervene at numerous points in this process and re-introduce the individual rationality. The word collaboration, in this case, does not mean seeking consensus forecasts, it means **collaborating on procedures** on how to implement this **process**. The VICS CPFR nine-step process offers many useful hints on how to do this and, as such, is extremely valuable.

Unfortunately, the final demand statement is a very dynamic and elusive category inclined to surprise everybody. Forecasting such a phenomenon is not easy, although a number of techniques produce satisfactory results. Some major advancements are needed in this domain too, but such an exploration would exceed the remit of this paper. We will assume that somehow it is possible to render acceptable demand forecasts. This paper, in the context of what was said above, is interested in how to handle such forecasts, in a dynamic fashion, to optimise the supply chain. Clearly, a technology capable of handling dynamic variables in real time across disparate environments is needed. Only a few years ago such a technology did not exist, which effectively means that supply chain collaborative forecasting scenarios are only now slowly becoming a reality. What technologies do we have in mind? The suggested solution is a suite of technologies clustered around a Service Oriented Architecture (SOA), primarily founded on web services; smart agents and real-time enterprise analytics.

5. Current technologies

One of largest challenges for any supply chain is application integration. The variety of disparate systems makes integration impossible and traditional point-to-point integration methods (or even some more contemporary middleware based techniques) are not sustainable. Some vendors hoped that making their ERP systems more open would address this problem, but it remains a fact that only a new and revolutionary approach to this problem will enable supply chains to share their processes seamlessly through fully integrated applications. Some newer technologies (although not new in inception) such as **Services Oriented Architecture** (SOA) indicate that a road towards a solution is opening up. It has to be said that the precursors of this architecture (such as DCOM or CORBA), were too proprietary to achieve universal acceptance. The new, web services based SOA, is truly an open architecture. We refer to software architecture as an abstraction of the run-time elements of a software system during some phase of its operation.

World Wide Web Consortium (W3C) describes **Web Service** as a software system identified by a URI (Uniform Resource Identifier), whose public interfaces and bindings are defined and described using XML[3]. Its functionality (definition) can be discovered by other software systems. These systems may then interact with the web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols. One can think about web services as software components that operate as either web objects or web applications. What is characteristic for them is that they are self-contained, self-describing and modular. They can be published, located and invoked across the Web. Once a web service is deployed, other applications (and other web services) can discover and invoke the deployed service.

[3] For details see <http://dev.w3.org/cvsweb/2002/ws/arch/wsa/wd-wsa-arch.html?rev=1.5>. Accessed: Dec 2004.

The above qualifies web services as prime candidates for implementing a variety of collaborative scenarios across the supply chain, including the CPFR. However, web services are in this case just a fundamental enabling technology, unable by itself to address more complex issues, such as the presence of the bullwhip effect. If web services based SOA is good enough to bring disparate systems in the supply chain together and fully automate this process, why do we think that it is not good enough to resolve "minor" technical issues, such as the bullwhip effect? The answer is, unfortunately, not so straight forward. It is certainly the right choice of the fundamental technology, but as such, it is not enough. A broader framework is needed. We need a major shift, from the focus on individual applications to the focus on **collaborative processes**. What kinds of technologies exist to enable such a shift?

Almost exclusively, all today's technologies and solutions were invented to support the strategies based on individual competitiveness. Regardless of the focus, i.e. efficiency (cost) focus or effectiveness (customer) focus, they were all built around the notion that individual companies should somehow be able to differentiate themselves from their competitors and gain some sort of competitive advantage. To use the language from the beginning of this paper: they are all based on the premise of individual rationality. We have indicated that CPFR procedures, based on today's technology, will inevitably produce the same behavioural patterns as the previous competitive strategies. What we need to find are the technologies that will suppress the individual rationality instincts and enable a collaborative rationale.

We need to point out that the CPFR issues are just some of the issues that will surface as a result of collaborative efforts. There is no doubt that numerous other completely unique sets of issues, characteristic to collaborative scenarios only, will emerge. We just do not have the exhaustive list of such issues, but it is reasonable to assume that they will be present. The fundamental question is, therefore, what kind of technology framework is likely to be able to tackle them adequately?

6. Towards a technology solution

The example of the bullwhip effect is a good point in case. Current technological and conceptual paradigms are unable to eradicate it. This is because the current paradigm is based on the notion that improving one's competitiveness, often at the expense of one's suppliers or customers, is the most beneficial strategy. A fundamental shift of emphasis away from organisations' functional units and software application units is needed. These elements can no longer be building blocks of a solution. A new unit, which transcends an enterprise, as a single, self-contained entity, is needed. This new unit, supporting the whole supply chain and supporting the collaboration, as a winning strategy, is needed. What do we mean by a new unit and what new theoretical framework is capable of providing a foundation for this new *modus operandi*?

In the current paradigm, an **object** (a software object, or a component) represents the most basic software unit that applications are built from/made of. These applications are designed to primarily support (automate) individual corporate functions. This philosophy has only been challenged over the last few years and the same application suites are being deployed to automate horizontal processes. However, a new unit that is needed is no longer an object, but a **process**. A process, in this case, provides a single view of a group of business activities undertaken by the supply chain in pursuit of a common goal. Individual applications, thanks to SOA, need to be converted into web services that will form a workflow transcending a single enterprise. Is such a framework emerging? Yes, it is.

The framework for this new paradigm is provided by the pi-calculus *(Milner 1999)*. Pi-calculus is simply an algebra for modelling systems of autonomous agents. These autonomous agents are called mobile systems. A mobile system is a form of communications network in which individual components interact with each other. The difference with the standard automation principles, where the component interaction is strictly prescribed, is that in the case of mobile systems the components are free and they interact spontaneously. This is the foundation of the **orchestration** principle, which replaces the principle of automation.

Participants in the supply chain are typical mobile systems. Mobility implies the notion of change, which is any modification of an existing relationship between two companies. A company can change its state by initiating an action (ship an order, pay a supplier, etc.). A company's partner in the supply chain interacts by attempting to change (or query) this state, which usually triggers some internal actions based on business rules. These internal actions enable the company to ultimately be in a state which is consistent with the one of its business partners. The company's actions, when executed, transition from one state to another. Interactions and actions, when assembled together, form the enterprise business processes.

Although the framework provided by the pi-calculus for this new paradigm has been known for some time, truly open architecture supporting this framework was missing. The emergence of the web services based SOA is the first instance of a vendor agnostic architecture that can support this framework. The only missing link is an application strategy that takes advantage of this framework and creates a new unit capable of supporting collaboration scenarios. This strategy, or initiative, emerged in the form of Business Process Management (BPM) *(Smith and Fingar 2003)*.

BPM should not be confused with the notion of Business Process Re-engineering (BPR), which was based on the principle that rather than just automating functions, processes need to be redefined, organisations changed accordingly and then mapped into a pan-enterprise application suite, such as an ERP (Enterprise Resource Planning) system. These solutions were technology (data) driven. BPM advocates one single definition of a business process, rendering different views of this same process. BPM as a solution, unlike the previous ones, is business (process) driven, not data driven[4].

A key element that makes BPM executable is a new language. Until recently several initiatives were competing for the market domination. The one, which seems to winning, is called BPEL, i.e. Business Process Execution Language, also known as BPEL4WS (Business Process Execution Language for Web Services), promoted by the OASIS consortium[5]. BPEL is a subset of the previously promoted BPML (Business Process Modelling Language) language. The most important characteristic

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[4] For a good overview of issues, see <http://www.delphigroup.com/research/whitepapers.htm>. Accessed: Dec 2004.

[5] For links see <http://www.bpmi.org/> and <http://www.oasis-open.org/home/index.php>. Accessed: Dec 2004.

of BPEL is that the emphasis is no longer on automation, but on orchestration. Just as UML (Unified Modelling Language) creates components (objects) that can be used in executables (automation), BPEL create processes as the fundamental units based on web services that can be shared between participants (orchestrated).

Today's technologies have been created with intention of achieving greater efficiency and effectiveness, based on the principle that brutal competition and individual competitive advantage are winning strategies. All the solutions have this principle implicitly embedded in their instances. The new world of supply chain optimisation makes an assumption that a winning strategy is based on collaboration, as much as it is based on competition. This automatically renders many current technologies inadequate. This paper advocates that a new paradigm is needed, although any attempt to define it will inevitably be somewhat fuzzy. A belief that pi-calculus, SOA, web services and BPEL, as manifestations of a new emerging technology, are capable of handling collaborative scenarios needs much more rigorous scrutiny. It also requires the world of academia to take the baton from industry and provide a new vision. Perhaps a new theoretical framework on how businesses should be run and integrated is also needed. Following an inductive approach, this paper attempted to look into CPFR as an example of a specific collaborative scenario, and concluded that current technologies will minimise some of the challenges identified, but will not eliminate them completely. A new paradigm is definitely needed.

7. Conclusion

Individual rationality, manifesting itself through the bullwhip effect, or as the tragedy of the commons, stands in the way of optimising inventory across the supply chain. A solution is some form of collaboration. As collaboration is founded on the principles of negotiations and consensus, this means that individual rationality inevitably creeps back into the process again. This paper advocates that a way to optimise the SCM and apply collaborative forecasting is to eliminate (minimise) human intervention and put more emphasis on shared processes. The challenge for automation in today's environment is that it must bridge disparate systems (islands of automation) and enable dynamic and real-time execution in order to optimise the system. This paper concludes that, unfortunately, this is not enough. A new paradigm is needed. A paradigm that will enable **orchestration** of independent services in the supply chain, defined as a single process. This new paradigm should be founded on a new **framework**, new **architecture**, new **technology** and new **execution languages**. Indications are that the framework is provided by the pi-calculus, the new architecture by SOA, the new technology by web services and the new languages by BPEL. More research in this domain is needed to see how this new paradigm can resolve some of the supply chain issues and, in particular, if it can stimulate new business models.

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